

A Comparison of the Radium Emanation Spectra Obtained by Different Observers

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So far the results are in satisfactory agreement with those obtained by Prof. Townsend, with Röntgen rays, and it is hoped to make further experiments and to see if it is possible to obtain positive ions with double the atomic charge by means of radium rays. Possibly the molecules of a gas are ionised in different ways by the α , β , and γ types of radiation, and it is not quite certain which kind of radiation had the predominating effect in the production of the ions in these experiments, though probably the greater numbers were due to the α -rays.

I am greatly indebted to Prof. Townsend for most valuable advice and assistance throughout.

A Comparison of the Radium Emanation Spectra obtained by different Observers.

By T. ROYDS, M.Sc., 1851 Exhibition Scholar.

(Communicated by Prof. E. Rutherford, F.R.S. Received November 26,—Read December 10, 1908.)

In 1904 Sir William Ramsay and Prof. Collie* gave a list of lines produced by the discharge in a vacuum tube containing radium emanation, but the uncertainty of these numbers made a redetermination desirable. A later determination by Mr. Cameron and Prof. Ramsay† was communicated to the Royal Society on June 25, 1908, and was published on August 27, together with corrections, and a final compilation of verified emanation lines added on August 5. After Prof. Rutherford had completed the measurements of the volume of the radium emanation, he and the writer were able to photograph the spectrum that had been observed in the course of this work, and we published in 'Nature,' July 9, 1908, the wave-lengths of the stronger lines observed by us in the emanation spectrum, and a more complete list, containing 73 lines, with an accuracy of 0.5 Å.U., was given in the 'Philosophical Magazine' of August, 1908. Measurements which I have recently made to within 0.1 Å.U. by means of a concave grating confirm the accuracy of our previous determinations.

The complete purification of the radium emanation demands a lengthy and painstaking procedure, and is a matter of considerable difficulty, for the volume of pure emanation available in our experiments would occupy at

* 'Roy. Soc. Proc.,' vol. 73, p. 470, 1904.

† 'Roy. Soc. Proc.,' vol. 81, p. 210, 1908.

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atmospheric pressure not more than one-tenth of a cubic millimetre. The vacuum tube employed must therefore be of small dimensions, and all traces of foreign gases have to be removed from the walls and the electrodes of the tube. In the experiments of Rutherford and Royds, using the method of purification recently developed by Prof. Rutherford,* a complete day's work was taken up before the vacuum tube was filled with the pure emanation.

We have observed the spectrum of the radium emanation at least eight times, and have obtained almost exactly the same spectrum on each occasion. We have drawn attention to variations in the relative intensities due to the presence of foreign gas. In the different experiments of Cameron and Ramsay, however, the spectrum is seen to vary considerably. In their first experiment, the spectrum consisted chiefly of hydrogen, together with nitrogen, and also (presumably) mercury,† and of the lines remaining, which alone are given in their list, the strongest are quite absent from our spectrum; a few of the fainter lines are probably identical with some of the strongest emanation lines. In the second experiment of Cameron and Ramsay, allowing for a possible error of 4 or 5 Å.U. in their measurements, the strongest lines in the spectrum are, roughly speaking, those strongest in our spectrum. At the end of their final list of August 5, Cameron and Ramsay state that our figures show a very close agreement with theirs. A careful examination shows, however, that there are striking differences too marked to be explained as errors in measurement or variations of intensity due to impurities, for many of the strongest lines are absent altogether from our spectrum, and also from their own previous determinations.

Investigating these differences several weeks ago, I noticed that after leaving out the well-marked emanation lines, the final spectrum of Cameron and Ramsay was almost identical with the xenon spectrum obtained by the discharge from a Leyden jar with spark gap.‡ An examination of the accompanying table shows that the spectrum attributed by them to the radium emanation is mainly a compound of the xenon spectra obtained with and without Leyden jar, the jar spectrum having been brought out, probably,

* 'Phil. Mag.,' May, 1908.

† In none of our photographs have the mercury lines been present, though the green line 5461 has been seen faintly in visual observations. Neither were the hydrogen lines, except H_{β} , seen when preliminary precautions had been taken for the removal of hydrogen from the electrodes.

‡ The author is reminded that Prof. Liveing had remarked last summer the similarity of this emanation spectrum to that of xenon; Sir J. Dewar reported the circumstance at the British Association meeting in September. The author is convinced that there is no real coincidence in the emanation spectrum with the spectra of any of the rare atmospheric gases.

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by the heaviness of the discharge employed. Practically the only strong xenon line not included in their list is the line 4862·69 (intensity 8), which was doubtless hidden by H_{β} 4861·49.

After eliminating the lines due to xenon from their last photograph containing 54 lines, there remain 11. Of these, eight are seen to be some of the strongest lines of our spectrum. Taking into account the complete list of Ramsay and Cameron's lines, including those printed in italics, which were seen only in previous photographs, the number of emanation lines amounts to 16; there are, of course, numerous coincidences within the accuracy of their measurements, of xenon lines with possible emanation lines.

Table.

Cameron and Ramsay's emanation spectrum.	Intensity.	Xenon (Baly).	Intensity without jar.	Intensity with jar.	Rutherford and Royds's values.	Intensity.
7050	2					
6150	2					
6101	2	6097·80	—	7		
6055	2	6051·36	—	7		
5980·5	2	5976·67	—	7		
5679·5	2					
5586	2				5582·2	8
5446	1	5439·19	—	8		
5419	4	5419·40	—	10		
5370	2	5372·62	—	8		
5335	3	5339·56	—	9		
5289	6	5292·40	—	10		
5083	2	5080·88	—	7	Probably 5084·45	4
4979	2	4978·49	—	4	Possibly 4979·02	4
4936	2				Possibly H (C. and R.)	
4920	3	4921·68	—	6		
		4919·85	—	4		
4883	2	4883·68	—	6		
4873	2	4876·68	—	7		
4843·5	10	4844·50	—	10		
4816	2	4818·15	—	4	Possibly 4817·33	4
4806·5	1	4807·19	6	1		
4768	2	4769·21	—	4		
4731·5	2	4734·30	8	1		
4722	4				4721·70	5
4695·5	2	4698·20	—	5		
		4697·17	7	—		
4681	5	4683·76	—	5	Possibly 4680·92	10
4672	7	4671·42	10	2		
4652·5	3	4652·15	—	6		
4645·5	6				4644·29	10
4626·5	10	4624·46	15	2	Possibly 4625·58	8
4616	2	4615·72	—	5		
4610	2				4609·40	7
4605	10	4603·21	—	10	Possibly 4604·46	4
4592	1	4592·22	—	6	Doubtful (C. and R.)	
4585	4	4585·65	—	10		
4578·5	3	4577·36	—	6	Possibly 4577·77	7
4545·5	2	4545·34	—	8		
4541	1	4541·03	—	8		
4532·5	2	4532·67	—	5		

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Cameron and Ramsay's emanation spectrum.	Intensity.	Xenon (Baly).	Intensity without jar.	Intensity with jar.	Rutherford and Royds's values.	Intensity.
4524	4	4524·83 4524·38	6 —	— 5	Possibly H (C. and R.)	
4509	4				4508·68	9
4505	2				4503·89	2
					Doubtful (C. and R.)	
4501	3	4501·13	10	2		
4481	4	4481·01	—	7		
4463·5	8	4462·38	—	20	Possibly 4460·0	10
4449	4	4448·28	—	10		
4441·5	<1	4441·08	—	3	Possibly 4439·88	2
4436·5	<1	4434·35	—	6	Possibly 4435·25	8
4416·5	4	4415·00	—	7		
4391	3	4395·91 4393·34	— —	10 10		
4349	6				4349·81	15
4331	4	4330·63	—	15		
4307	2				4308·3	10
4246	4	4245·54	—	10		
4239	3	4238·37	—	10		
4204	5				4203·39	10
4189	3	4193·25 4180·20	8 —	8 10	Probably 4188·2	5
4167	6				4166·6	20
4114	3	4116·25	—	7	Probably 4114·71	7
4018·5	4				4017·90	10
3982	8				3981·83	12
3973	6				3971·71	9
3958·5	3				3957·30	7
3879·5	10	3880·60 3877·95	— —	6 8		
3866·5	6				3867·6	4
3856·5	4					

It is not possible to explain the presence of so large a quantity of xenon as must have been in the spectrum tube as being due to a leakage of air into the apparatus. Prof. Rutherford and I have made special experiments to test whether xenon was present with our preparations of emanation, but could not detect any trace of this gas. It is probable that there has been, in the experiments of Cameron and Ramsay, an unsuspected contamination with xenon.

Cameron and Ramsay attribute a line at 4058·5 to the active deposit of the radium emanation, since its relative intensity increases with the length of time that the discharge has passed. Mercury lines will, of course, behave similarly as the emanation is driven into the walls. It appears probable that they have overlooked a mercury line at 4057·9, which is present, according to Eder and Valenta, in the vacuum tube discharge at ordinary temperatures, with an intensity 4 compared with intensity 10 for the mercury line 4046·8.